



## **Allocation of Deep Space Network Ground System Tracking and Communications Assets During the 2020-2021 Timeframe of the “Mars Armada”**

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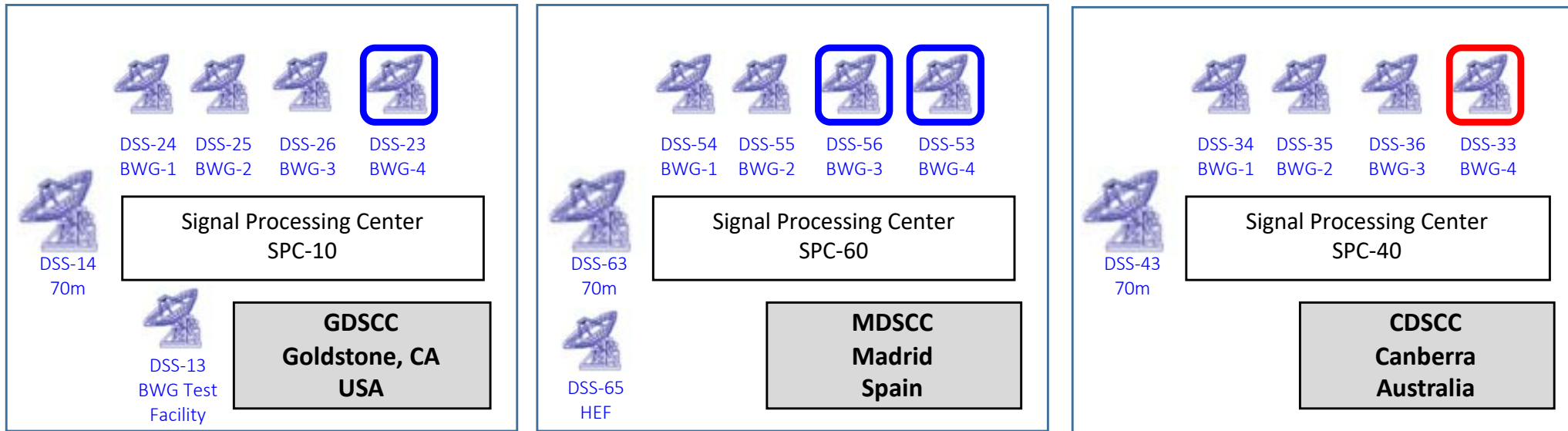
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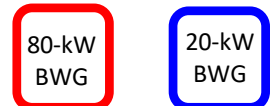
**Jet Propulsion Laboratory**  
California Institute of Technology



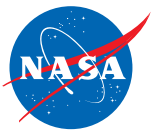
# NASA Deep Space Network (DSN)



New Antennas Not Completed Yet



- 70m antennas (3)
- 34m antennas (9)
  - DSS-65 retirement in 2020; new antennas DSS-56 & DSS-53 to be completed in 2020



# Deep Space Network (DSN) Loading in 2020-2021

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- The DSN has currently 12 operational antennas in three DSCCs
- At any time, the DSN supports 35-40 missions
- DSN scheduling processes and tools match mission needs to DSN antenna availability
  - These tools work best when missions are distributed evenly across the sky and across the DSN complexes
  - When multiple missions are clustered (e.g. all launch and arrive at Mars together), likelihood of local DSN overload increases
- Mars launch opportunities occur every ~ 26 months (e.g. May 2018, July 2020)
  - Arrival at Mars is ~ 6 months later
- We have evaluated 2020-2021 Mars DSN Loading



## DSN Loading in 2020-2021 (cont.)

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- The DSN basically operates at capacity
- “Demand Excess” of ~ 30% (or more) is often seen years in advance when early, preliminary user requests are compared to antenna availability projections
  - 2012: 30% (MSL)
  - 2014-2016: 28%
  - 2018-2019: 29%-34%
  - 2020-2021: 26%-30% (latest study update in Jan 2018 with Sardinia antenna)
- The DSN scheduling process is resilient, reducing Demand Excess from ~ 30% (6+ months prior to execution) to < 15% (4 months prior), converging to eliminate residual conflicts by 3 months out



# 2020-2021 Mars DSN Loading Study **Status in June 2017**

- New Mars missions launch in mid-2020 and arrive at Mars in early 2021 within ~ 8-week window

## Mars Missions Operating Now or by 2020-21

1. TGO (orbiter) – assumed operating 2020-21
2. MAVEN (orbiter) – assumed operating 2020-21
3. Curiosity (rover) – assumed operating 2020-21
4. INSIGHT (lander) – assumed operating 2020-21
5. MRO (orbiter) – assumed operating 2020-21
6. MOM-1 (orbiter) – assumed operating 2020-21
7. MER (rover) – assumed operating 2020-21
8. ODY (orbiter) – assumed operating 2020-21
9. MEX (orbiter) – assumed NOT operating 2020-21

## 2020-2021 New Mars Missions (6 with DSN Support)

1. NASA/JPL Mars 2020 (Rover) (EDL) 
2. ESA ExoMars Rover and Surface Platform (RSP) (EDL) 
3. SpaceX Red Dragon lander 1 (EDL)
4. [SpaceX Red Dragon lander 2 (EDL)] 
5. ISRO MOM-2 orbiter (MOI) 
6. UAE EMM orbiter (MOI) 
7. *China NSSC 2020 Mars Mission (not directly supported by DSN)* 

**Originally expected 8+ existing missions plus 7 new arrivals at Mars**  
**Accommodating all these missions in one part of the sky looked challenging**



# 2020-2021 Mars DSN Loading Study **Status in Jan 2018**

- New Mars missions launch in mid-2020 and arrive at Mars in early 2021 within ~ 8-week window

## **Mars Missions Operating Now or by 2020-21**

1. TGO (orbiter) – assumed operating 2020-21
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7. MER (rover) – assumed operating 2020-21
8. ODY (orbiter) – assumed operating 2020-21
9. MEX (orbiter) – assumed NOT operating 2020-21

## **2020-2021 New Mars Missions (3 with DSN Support)**

1. NASA/JPL Mars 2020 (Rover) (EDL)



2. ESA ExoMars Rover and Surface Platform (RSP) (EDL)



- ~~3. SpaceX Red Dragon lander 1 (EDL)~~

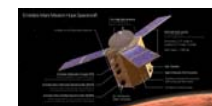
- ~~4. [SpaceX Red Dragon lander 2 (EDL)]~~



- ~~5. ISRO MOM-2 orbiter (MOI)~~



3. UAE EMM orbiter (MOI)



4. China NSSC 2020 Mars Mission (not directly supported by DSN)



**Now expecting 8+ existing missions plus only 3 new DSN-supported arrivals**

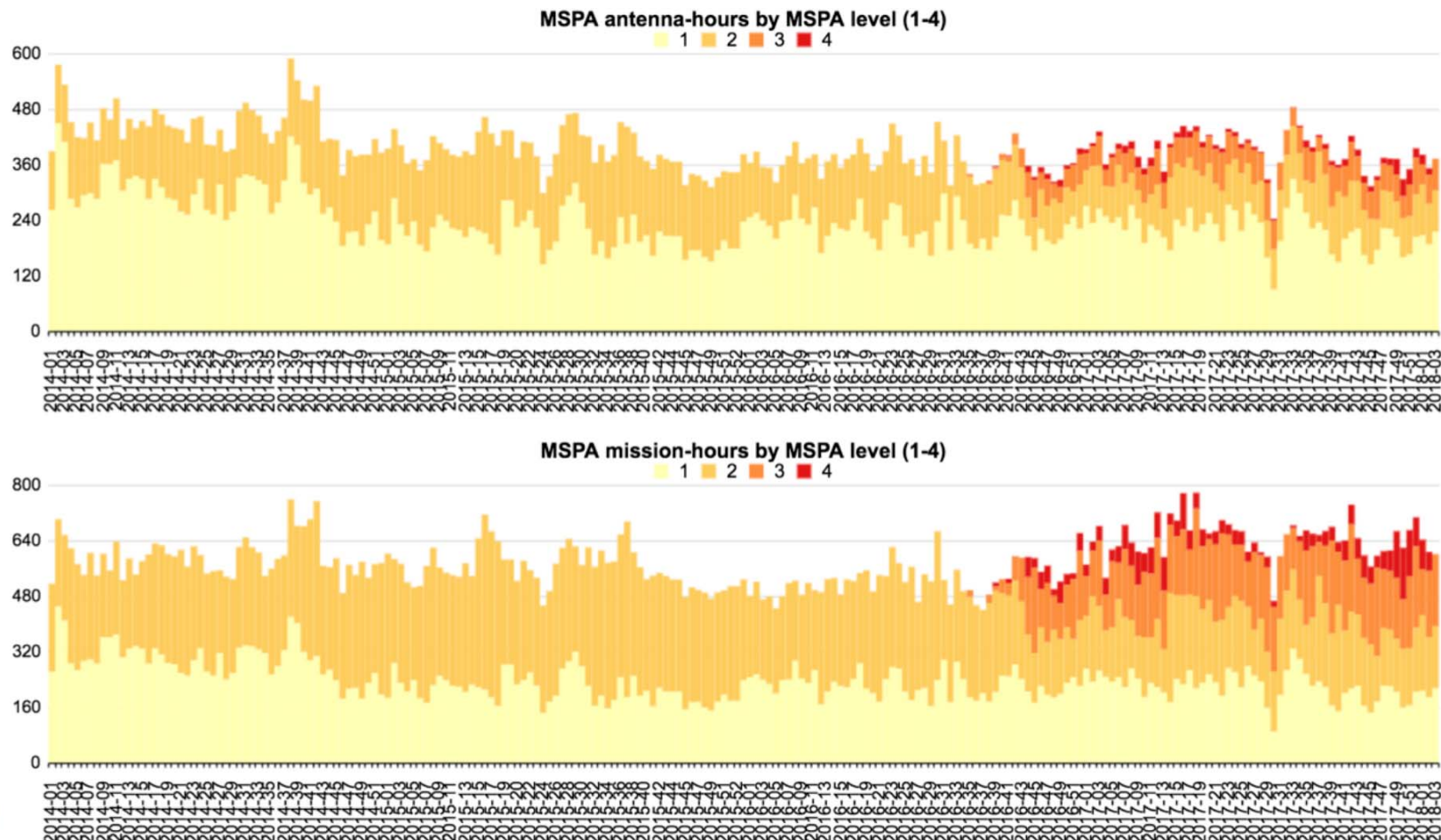
**This is a more “typical” pattern in a Mars launch year**

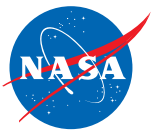




## Mitigations to Anticipated DSN Loading

- Multiple Spacecraft per Antenna – MSPA. Can currently support 4 spacecraft simultaneously with one DSN antenna
  - MSPA is not utilized to capacity and could accommodate additional Mars spacecraft
  - Missions requiring lots of 2-way tracking use MSPA less because the uplink must be shared





## Mitigations to Anticipated DSN Loading (cont.)

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- Two new DSN 34m BWG antennas in Madrid will come on line in 2020
    - Plus use of Sardinia antenna (part-time) reduces DSN loading by an additional 2% on average -- more during critical periods if strategically scheduled
  - Sardinia, Morehead State University antennas and 4-MSPA can lessen impact of cubesats requesting deep space antenna coverage
    - Cubesats typically operate telecom only for short periods (thermal impacts)
  - JPL Navigation is re-assessing amount of 2-way Doppler required for safe mission navigation. Some reductions appear to be possible, saving antenna time.
  - Recent reduction in number of new DSN-supported Mars missions in 2020-2021 from 6 to 3 notably reduces DSN demand at Mars to more “typical” levels
- => DSN scheduling process is resilient, reducing Demand Excess from ~ 30% (6+ months prior to execution) to < 15% (4 months prior), converging to eliminate residual conflicts by 3 months out**
- => Existing DSN scheduling methods, plus margin of safety from recent mitigations, should readily accommodate 2020-2021 Mars mission demand**





# Mars DSN Antenna Demand and Scheduling Progression

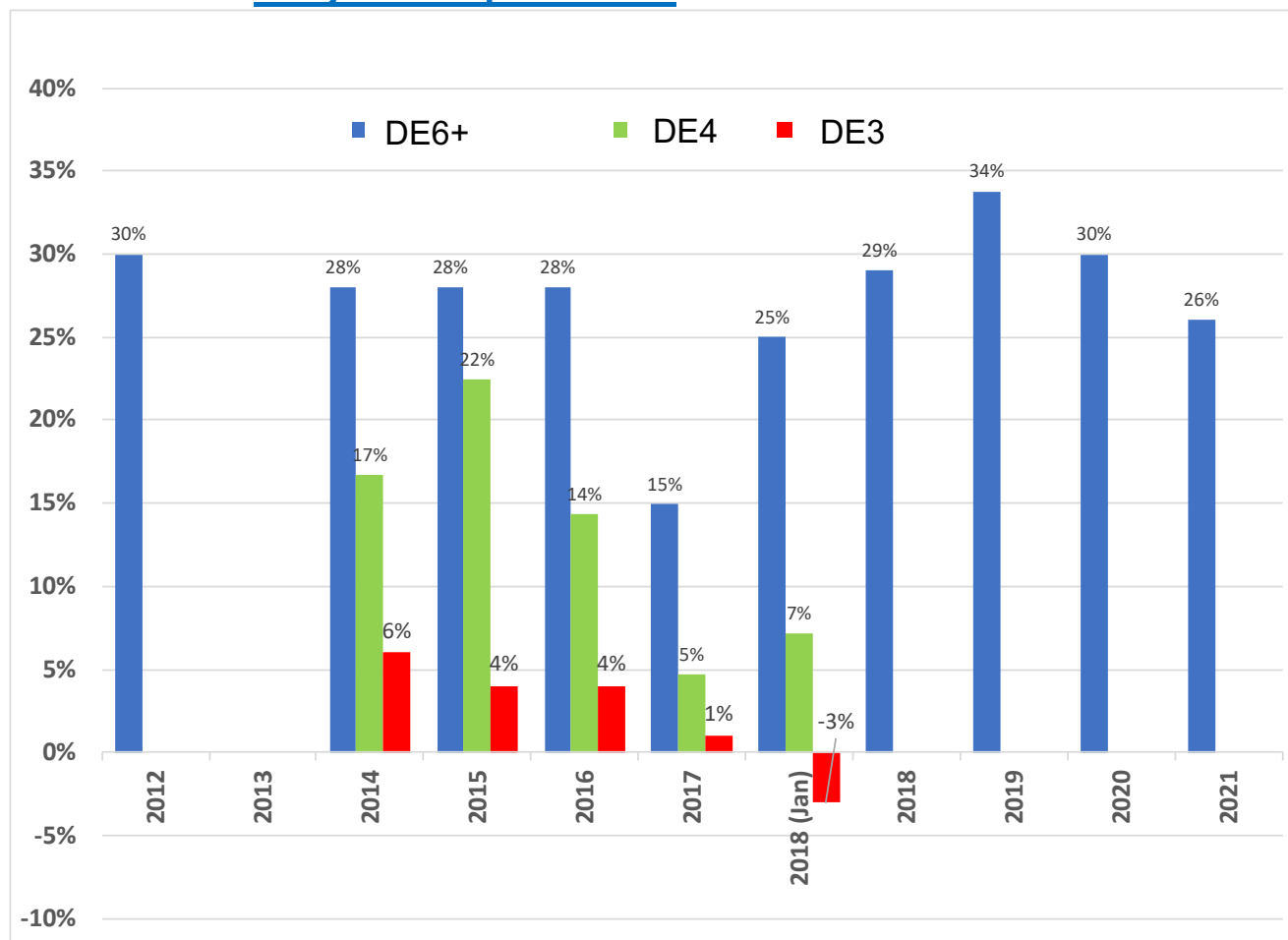
(1) Demand Excess 6-48 months in advance with early user inputs DE6+

(2) Demand Excess DE4 based on final user requests ~ 4 months before execution

(3) Final schedule 3 months before execution has Demand Excess DE3 ( $\pm 4\%$ ), basically a conflict-free schedule.

Mitigations to further reduce loading:

- New 2020 Mars launches now reduced from 6 to 3 (M2020, EMM, RSP)
- Building two new 34m DSN antennas
- Augmenting DSN with more antennas (Sardinia, Morehead St, etc.)
- Adjusting DSN maintenance schedules to maximize availability at peak times
- Maximizing MSPA, revisiting missions' large requests for DSN 2-way Doppler
- Accommodating key and critical events during scheduling negotiations



MSL arrival and landing on Mars

DSCO launch; MMS launch (4 S/C);  
NH Pluto encounter; DSS63  
downtime; DSS45 retirement

New Mars missions launch  
within 8 week window and  
arrive within 8 week  
window



# SUMMARY

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- ⇒ **DSN scheduling process is resilient. A conflict-free schedule is determined approximately 12 weeks in advance of execution.**
- ⇒ **To guard against excessive antenna loading, the DSN has implemented mitigations that simultaneously reduce DSN antenna demand while increasing the supply**
- ⇒ **Reduction in number of Mars launches in 2020 further alleviates much of the anticipated increase in DSN antenna loading in 2020-2021 and beyond**